REMARKS

This amendment is responsive to the Office Action mailed October 31, 2007. Reconsideration and allowance of the claims 1, 2, 4-15, 19, and 20 are requested.

The Office Action

Claims 1-20 were examined in the Office Action mailed Oct. 31st.

Claims 1-20 stand rejected under 35 U.S.C. § 102(a) as being allegedly anticipated by Tsao et al., *MR angiography at high acceleration using feedback regularized SENSE and variable density k-space sampling*, Proc. Int'l. Soc. Mag. Reson. Med. vol. 11, page 484 (2003) (hereinafter "Tsao").

The Tsao reference

Tsao discloses regularized SENSE using stepwise variable density sampling, in which a central portion has less undersampling than a peripheral region. In the quantitative example set forth in Tsao, the central portion is acquired at 2× undersampling, while the peripheral region is acquired at either 5× or 8× undersampling. Both regions are acquired using Cartesian sampling which Tsao advocates for its efficiency.

Tsao performs two reconstruction operations, both of which use the SENSE Equation [1] set forth in Tsao. The first SENSE reconstruction reconstructs the 2× undersampled central k-space and omits the noise covariance matrix θ. The second SENSE reconstruction reconstructs the combination of the 2× undersampled central region and the 5× or 8× undersampled peripheral region, this time including the noise covariance matrix θ determined from the first pass image.

Claims 1-8 present patentable subject matter

Claim 1 has been amended to call for the the higher density portion disposed at or near the center of k-space to not be undersampled, and for constructing one or more regularization images from the higher density portion of the variable density sensitivity encoded data disposed at and adjacent the center of k-space, the constructing not including unfolding of folded images.

Tsao does not disclose or fairly suggest not undersampling the higher density portion disposed at or near the center of k-space. To the contrary, Tsao discloses undersampling this region, but at a higher sampling density than the peripheral region.

Tsao further does not disclose or fairly suggest constructing one or more regularization images from the higher density portion of the variable density sensitivity encoded data disposed at and adjacent the center of k-space, the constructing not including unfolding of folded images. To the contrary, Tsao teaches using the first pass reconstruction being a SENSE reconstruction employing unfolding of folded images using Tsao's SENSE Equation [1].

Claim 4 the higher density portion of the variable density sensitivity encoded data that is not undersampled to span about one-eighth of a k-space range of the variable density sensitivity encoded data. Nothing in Tsao discloses or fairly suggests this subject matter.

Claim 5 calls for the higher density portion of the variable density sensitivity encoded data acquired by each antenna to be oversampled and contain redundant data. To the contrary, Tsao discloses 2× <u>under</u>sampling of the higher density central k-space region.

Claim 7 calls for acquiring the higher density portion disposed at or near the center of k-space with a uniform k-space sampling density that is not undersampled, and acquiring undersampled k-space data away from the center of k-space using a k-space sampling density that decreases smoothly with distance away firm the higher density portion. To the contrary, Tsao discloses a stepwise sampling density profile, in which the central k-space region is sampled at 2× undersampling and the peripheral k-space region is sampled at either 5× undersampling or 8× undersampling. The result is a stepwise profile with an abrupt change in sampling density at the boundary, rather than a smoothly decreasing sampling density as called out in claim 7.

Claim 8 depends from claim 7 and further calls for the sampling density transition between the higher density portion and the undersampled k-space data away from the center of k-space to have one of a linear and a Gaussian shape. To the contrary, the sampling density transition of Tsao is an abrupt step.

Claims 9-15 present patentable subject matter

Claim 9 has been placed into independent form including all limitations of original base claim 1. Claim 9 calls for acquiring variable density sensitivity encoded data with a higher density at and adjacent a center of k-space and with a lower, undersampled density away from the center of k-space using a non-Cartesian trajectory, the higher density portion of the variable density sensitivity encoded data being defined by a geometry of the non-Cartesian trajectory, constructing one or more regularization images from the higher density portion of the variable density sensitivity encoded data disposed at and adjacent the center of k-space, and reconstructing the variable density sensitivity encoded data into an unfolded reconstructed image, the reconstructing including reconstructing the higher and lower density variable density sensitivity encoded data into a plurality of folded images, and unfolding the folded images to form the unfolded image using the one or more regularization images.

With reference to FIGURES 3 and 4 of the present application, it is recognized in the present application that certain non-Cartesian trajectories such as radial trajectories (FIGURE 3) and spiral trajectories (FIGURE 4) inherently define a higher density sampling region at and adjacent the center of k-space, even without intentional variation in the sampling rate. Claim 9 calls out a method which uses such non-Cartesian sampling advantage of this to provide a variable density acquisition with a higher density at and adjacent a center of k-space and with a lower, undersampled density away from the center of k-space.

Tsao does not remotely suggest these aspects of claim 9, much less anticipate these aspects as alleged in the Office Action. To the contrary, Tsao positively advocates using Cartesian SENSE for efficiency, and advocates the use of grid-like (i.e., Cartesian) sampling patterns.

Claim 10 calls for acquiring a plurality of radial k-space sampling trajectories, the higher density portion of the variable density sensitivity encoded data being defined by a convergence of the plurality of radial k-space sampling trajectories at or near the center of k-space. Tsao does not suggest, much less anticipate, such radial k-space sampling trajectories in the context of regularized SENSE.

Claim **11** calls for acquiring a spiral k-space sampling trajectory, the higher density portion of the variable density sensitivity encoded data being defined by a center region of the spiral k-space sampling trajectory. Again, Tsao does not suggest, much less anticipate, such a spiral k-space sampling trajectory in the context of regularized SENSE.

Claim **14** calls for the higher density portion of the variable density sensitivity encoded data to not be undersampled. To the contrary, Tsao discloses a 2× undersampling of central k-space region, and does not suggest, much less anticipate, the higher density portion of the variable density sensitivity encoded data <u>not</u> being undersampled.

Claims 19-20 present patentable subject matter

Claim **20** has been placed into independent form including all limitations of original base claim 16. Claim 20 calls for a magnetic resonance imaging apparatus comprising: a plurality of radio frequency coils acquiring variable density sensitivity encoded data including a higher density portion disposed at or near the center of k-space acquired with a uniform k-space sampling density that is not undersampled, and undersampled k-space data acquired away from the center of k-space using a k-space sampling density that decreases smoothly with distance away from the higher density portion; a reconstruction processor that for each coil reconstructs a regularization image reconstructed from a higher density portion of the variable density sensitivity encoded data disposed at or near a center of k-space acquired by that coil, and a folded image reconstructed from the variable density sensitivity encoded data acquired by that coil; and an unfolding processor that unfolds the folded images, the unfolding being regularized by the regularization images.

Tsao does not fairly suggest, much less anticipate, a plurality of radio frequency coils acquiring variable density sensitivity encoded data including a higher density portion disposed at or near the center of k-space acquired with a uniform k-space sampling density that is not undersampled, and undersampled k-space data acquired away from the center of k-space using a k-space sampling density that decreases smoothly with distance away from the higher density portion. To the contrary, Tsao discloses 2× <u>under</u>sampling of the central k-space region. Further,

Tsao discloses a k-space sampling density that abruptly decreases at the transition from the higher density portion to the undersampled region, rather than smoothly decreasing with distance away from the higher density portion as recited in claim 20.
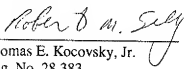
CONCLUSION

For the reasons set forth above, it is submitted that all claims distinguish patentably over the references of record and meet all statutory requirements. An early allowance of claims 1, 2, 4-15, 19, and 20 is requested.

In the event the Examiner considers personal contact advantageous to the disposition of this case, he is requested to telephone Thomas Kocovsky at (216) 861-5582.

Respectfully submitted,

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